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FORM PTO-1390 (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	
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U.S. APPLICATION NO (If known, see 37 CFR 1.5)	
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INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE
PCT/EP01/00494	17 January 2001 (17.01.01)
PRIORITY DATE CLAIMED	
17 January 2000 (17.01.00)	

TITLE OF INVENTION CDMA RECEIVER

APPLICANT(S) FOR DO/EO/US INFINEON TECHNOLOGIES AG; DOETSCH, Markus; KELLA, Tideya; SCHMIDT, Peter; JUNG, Peter; PLECHINGER, Joerg and SCHNEIDER, Michael

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND or SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [X] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [X] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [X] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information include

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1
12. [ ] An assignment document for recording. A separate cover sheet
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [X] Other items or information:

Copy of first page of published PCT application; Copy of International Search Report

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Date of Deposit 14.9.01

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231. Katrina T. Holland, Lillian S. Glenn, Amy J. Martin, Karen S. Flynn, Paige E. Snyder, Shaylor E. Dunn. April N. Williams

April N. Williams

COPY

JC16 Rec'd PCT/PTO SEP 1 4 2001

US APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/936771	PCT/EP01/00494	1406/18

21. ☒ The following fees are submitted:

	CALCULATIONS PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):	
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a (2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**	
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**	
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	13 -20 =	0	**x $18.00**	$ 0.00
Independent claims	1 -3 =	0	**x $80.00**	$ 0.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			**+ $270.00**	$ 0.00
TOTAL OF ABOVE CALCULATIONS =				$ 860.00
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +				$ 0.00
SUBTOTAL =				$ 860.00
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$ 0.00
TOTAL NATIONAL FEE =				$ 860.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0.00
TOTAL FEES ENCLOSED =				$ 860.00
			Amount to be refunded:	$
			charged:	$

a. ☒ A check in the amount of $ 860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-0426. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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25297
PATENT TRADEMARK OFFICE

Richard E. Jenkins
SIGNATURE

Richard E. Jenkins
NAME

28,428
REGISTRATION NUMBER

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Doetsch et al.

Group Art Unit: Not Assigned

Serial No.: Not Assigned

Examiner: Not Assigned

Filed: Herewith

Docket No.: 1406/18

For: CDMA RECEIVER

* *

PRELIMINARY AMENDMENT

Honorable Commissioner for Patents
BOX PCT
Washington, D.C. 20231

Dear Sir:

Kindly amend the subject application as follows:

IN THE SPECIFICATION:

Please insert the paragraph heading on page 1 of the English translation of the subject application, before line 5, as follows:

--Technical Field --.

Please insert the paragraph heading on page 1 of the English translation of the subject application, before line 10, as follows:

--Related Art --.

Please insert the paragraph heading on page 3 of the English translation of the subject application, before line 33, as follows:

--Summary of the Invention --.

Please insert the paragraph heading on page 6 of the English translation of the subject application, before line 7, as follows:

--Brief Description of the Drawings--.

Please insert the paragraph heading on page 6 of the English translation of the subject application, before line 27, as follows:

--Detailed Description of the Invention--.

IN THE CLAIMS:

Please delete the paragraph heading "Patent Claims" on page 13 of the English translation of the subject application, and insert in place thereof the paragraph heading on page 13 of the English translation of the subject application, line 1, as follows:

--CLAIMS--

Please insert the paragraph heading on page 13 of the English translation of the subject application, after the above-noted heading and before claim 1, the following:

-- What is claimed is: --.

Please amend claims 1-13 as follows:

1. (Amended) CDMA receiver for receiving a CDMA signal, which is transmitted at the chip clock rate from a transmitter via various signal paths of a physical transmission channel, in a multi-subscriber environment having:

(a) a receiving device for receiving the CDMA signal;

(b) a Rake receiving circuit having a number of parallel-connected delay devices for detection of the signal components of the CDMA signal which are transmitted via the various signal paths;

(c) a channel estimation circuit for estimating channel coefficients h of a transmission channel H by means of a predetermined reference data sequence which is contained in the received CDMA signal;

(d) a weighting coefficient calculation device for calculating weighting coefficients m for the various signal components of the CDMA signal as a function of the estimated channel coefficients h and of stored spreading and scrambling codes;

(e) a weighting circuit for weighting the signal components with the calculated weighting coefficients m; and having

(f) a combiner for combining the weighted signal components to form an estimated received data signal.

2. (Amended) CDMA receiving according to Claim 1, wherein the weighting coefficient calculation device is connected to a memory device.

3. (Amended) CDMA receiving according to Claim 1, wherein spreading codes C_{SP} of the subscriber and scrambling codes C_{SC} from the transmitter are stored in the memory device.

4. (Amended) CDMA receiver according to claim 1, wherein the combiner is an adder for adding the weighted signal components.

5. (Amended) CDMA receiver according to claim 1, wherein the reference data sequence is processed by the channel estimation circuit at the chip clock rate T_C.

6. (Amended) CDMA receiving according to claim 1, wherein the delay devices of the Rake receiving circuit delay the received CDMA signal by an associated time delay τ differing by precisely one chip clock cycle T_C between the various delay devices.

7. (Amended) CDMA receiver according to claim 1, wherein the receiving device is a receiving antenna, which is followed by a sampling circuit for sampling the CDMA receiving signal.

8. (Amended) CDMA receiver according to claim 1, wherein an output circuit is provided for outputting the reference data sequence from the received CDMA received signal.

9. (Amended) CDMA receiver according to claim 1, wherein the weighting circuit comprises a large number of multiplication circuits, which are each followed by a delay device.

10. (Amended) CDMA receiver according to claim 1, wherein a buffer store is provided for buffer storing the sampled received data from the CDMA received signal.

11. (Amended) CDMA receiver according to claim 1, wherein the channel estimation circuit is a DSP processor.

12. (Amended) CDMA receiver according to claim 1, wherein the weighting coefficient calculation device is a DSP processor.

13. (Amended) CDMA receiver according to claim 2, wherein the memory device is an RAM memory.

REMARKS

The amendments to the specification as set forth above are intended to clarify and set apart the various sections of the subject application.

The amendments to the claims as set forth above are intended to remove all multiple dependent claims from the subject application and to more particularly point out and distinctly claim the subject invention.

Attached hereto is a marked-up version of the specification and claims 1-13, which illustrates all of the changes made to the specification and claims pursuant to 37 CFR §1.121. The attached page is captioned "**Version With Markings To Show Changes Made**". Deleted language is bracketed and added language is underlined.

The Commissioner is hereby authorized to charge any deficiencies or credit any overpayments in connection with the filing of this correspondence to Deposit Account No. **50-0426**.

Respectfully submitted,

JENKINS & WILSON, P.A.

Date: 9-14-01

By: Richard E. Jenkins

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1406/18 REJ/lsg

25297
PATENT TRADEMARK OFFICE

Serial No.: Not yet assigned

Version With Markings To Show Changes Made

IN THE SPECIFICATION:

The paragraph heading has been inserted on page 1 of the English translation of the subject application, before line 5, as follows:

Technical Field

The paragraph heading has been inserted on page 1 of the English translation of the subject application, before line 10, as follows:

Related Art

The paragraph heading has been inserted on page 3 of the English translation of the subject application, before line 33, as follows:

Summary of the Invention

The paragraph heading has been inserted on page 6 of the English translation of the subject application, before line 7, as follows:

Brief Description of the Drawings

The paragraph heading has been inserted on page 6 of the English translation of the subject application, before line 27, as follows:

Detailed Description of the Invention

IN THE CLAIMS:

The paragraph heading has been inserted on page 13 of the English translation of the subject application, before line 1, as follows:

CLAIMS

The paragraph heading has been inserted on page 13 of the English translation of the subject application, before claim 1, as follows:

What is claimed is:

1. (Amended) CDMA receiver for receiving a CDMA signal, which is transmitted at the chip clock rate from a transmitter via various signal paths of a physical transmission channel, in a multi-subscriber environment having:

(a) a receiving device [(1)] for receiving the CDMA signal;

(b) a Rake receiving circuit [(6)] having a number of parallel-connected delay devices [(7_1-7_n)] for detection of the signal components of the CDMA signal which are transmitted via the various signal paths;

(c) a channel estimation circuit [(20)] for estimating channel coefficients h of a transmission channel H by means of a predetermined reference data sequence which is contained in the received CDMA signal;

(d) a weighting coefficient calculation device for calculating weighting coefficients m for the various signal components of the CDMA signal as a function of the estimated channel coefficients h and of stored spreading and scrambling codes;

(e) a weighting circuit [(12)] for weighting the signal components with the calculated weighting coefficients m; and having

(f) a combiner [(15)] for combining the weighted signal components to form an estimated received data signal.

2. (Amended) CDMA receiving according to Claim 1, [characterized in that] wherein the weighting coefficient calculation device [(12)] is connected to a memory device [(23)].

3. (Amended) CDMA receiving according to Claim 1[or 2, characterized in that], wherein spreading codes C_{SP} of the subscriber and scrambling codes C_{SC} from the transmitter are stored in the memory device [(23)].

4. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 1, wherein the combiner [(15)] is an adder for adding the weighted signal components.

5. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 1, wherein the reference data sequence is processed by the channel estimation circuit [(20)] at the chip clock rate T_C.

6. (Amended) CDMA receiving according to [one of the preceding claims, characterized in that] claim 1, wherein the delay devices [(7_1-7_n)] of the Rake receiving circuit [(6)] delay the received CDMA signal by an associated time delay τ, with the time delay τ differing by precisely one chip clock cycle T_C between the various delay devices.

7. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 1, wherein the receiving device [(1)] is a receiving antenna, which is followed by a sampling circuit for sampling the CDMA receiving signal.

8. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 1, wherein an output circuit [(17)] is provided for outputting the reference data sequence from the received CDMA received signal.

9. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 1, wherein the weighting circuit [(13)] comprises a large number of multiplication circuits [(10_1-10_n)], which are each followed by a delay device [(71-7_n)].

10. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 1, wherein a buffer store is provided for buffer storing the sampled received data from the CDMA received signal.

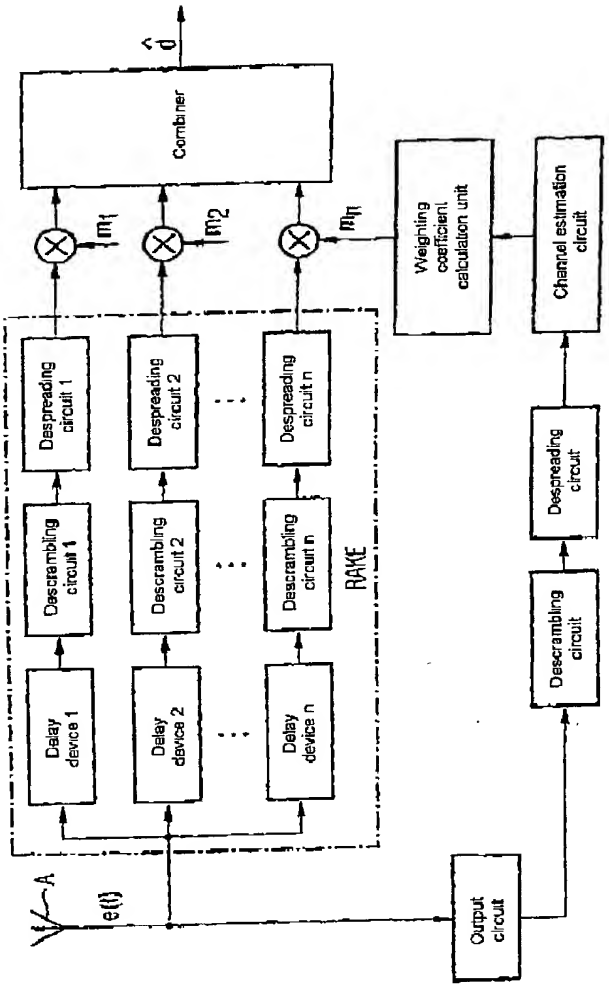
11. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 1, wherein the channel estimation circuit [(20)] is a DSP processor.

12. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 1, wherein the weighting coefficient calculation device [(12)] is a DSP processor.

13. (Amended) CDMA receiver according to [one of the preceding claims, characterized in that] claim 2, wherein the memory device [(23)] is an RAM memory.

2/3

FIG 4 Prior art



Description

CDMA receiver

The invention relates to a CDMA receiver for receiving a CDMA signal, which is transmitted at the chip clock rate from a transmitter via various signal paths of a physical transmission channel.

The CDMA method (CDMA: Code Division Multiple Access) is a channel access method which is used in cellular systems, in particular in the mobile radio field. In this case, a narrowband signal is spread by means of a code to form a broadband signal. The subscriber signals from those subscribers who are active at the same time in the same subscriber frequency band are band-spread by the application of subscriber-specific CDMA codes. In the CDMA method, a fingerprint, which is as unique as possible, is printed onto each data symbol. This can be achieved by using orthogonal OVSF coders.

Figure 1 shows one cell in a cellular mobile radio system, in which three subscribers or users U1, U2, U3 are located within one mobile radio cell and receive a CDMA transmitted signal from the base station BS. A subscriber U receives a CDMA signal from the base station BS via a physical channel path H. The physical channel H comprises a large number of signal propagation paths which occur, for example, owing to reflections or signal scatter.

Figure 2 shows a simple model for data transmission from the base station to a subscriber U. A data stream $d(t)$ is produced in the base station, and is spread, coded and scrambled to form a transmitted signal $S(\tau)$ by means of a CDMA transmitter in the base station. The transmitted signal passes via the physical channel H as a received signal $e(\tau)$ to the subscriber's CDMA receiver. In the CDMA receiver, the received signal is

descrambled and despread or decoded to form an estimated data stream $\hat{d}(t)$, which normally corresponds to the data stream d(t) which the CDMA transmitter receives.

Figure 3 shows a CDMA transmitter according to the prior art. The transmitter receives data streams d1, d2, ... d_K, which are intended for different subscribers, from different data sources in parallel. The data streams d are spread and coded in an associated spreading circuit, using OVSF codes that are orthogonal in pairs. The spread and coded data streams are fed to an adder. The adder superimposes the various spread and coded data streams, and passes the integrated data stream on to a scrambling circuit. The superimposed data stream is scrambled and is emitted from the base station BS as the transmitted data stream s to the subscribers U. The scrambling process is used by the subscriber to identify the base station BS.

Figure 4 shows a CDMA receiver according to the prior art. The CDMA received signal e(t) received by the subscriber U via a receiving antenna A is fed to a Rake receiving circuit. The Rake receiving circuit has a number of signal paths which run in parallel with one another and each comprise a delay device, a descrambling circuit and a despreading circuit. The various parallel-connected signal paths are also referred to as Rake fingers. The Rake receiving circuit is used to detect the various signal components of the transmitted CDMA transmitted signal, which are produced by the various signal paths of the physical transmission channel. In this case, the delay device takes account of the various signal propagation time delays on the various signal paths of the transmission channel. The delay times in the delay devices are adjustable, and can be adapted to the transmission channel during reception of the CDMA signal. The various signal components in the CDMA received signal

are descrambled in the various Rake fingers, and are then despread by means of an OVSF code. On the output side, the CDMA signal components detected by the Rake fingers are multiplied by weighting coefficients by means of multipliers, and are converted in a combiner into an estimated data signal $\hat{d}$. The combiner is an addition circuit which adds the various weighted signal components. The weighting coefficients m are calculated in a weighting coefficient calculation unit on the basis of estimated channel coefficients h, which are determined by a channel estimation circuit. This is done by outputting a reference data sequence by means of an output circuit from the CDMA received signal e(t), which sequence is descrambled in a descrambling circuit and, after despreading in a despreading circuit, is passed to the channel estimation circuit.

The CDMA receiver according to the prior art as shown in Figure 4 has the disadvantage, however, that it is impossible to eliminate signal interference between different subscribers or users within one mobile radio cell. The CDMA receiver illustrated in Figure 4 is suitable only for single subscriber detection, in which case the intersymbol interference and the multiple-access interference between the subscribers cannot be overcome, so that only a low spectrum efficiency can be achieved. The CDMA receiver shown in Figure 4 has no data relating to the spreading codes C_{sp} of the other subscribers in the cell. It thus cannot take any account of or suppress interference caused by the signals transmitted by other subscribers in that cell.

The object of the present invention is thus to provide a CDMA receiver in which signal interference which is caused by signals transmitted by other subscribers is overcome.

According to the invention, this object is achieved by a CDMA receiver having the features specified in Patent Claim 1.

The invention provides a CDMA receiver for receiving a CDMA signal, which is transmitted at the chip clock rate from a transmitter via various signal paths of a physical transmission channel, in a multi-subscriber environment, having a receiving device for receiving a CDMA signal, having a Rake receiving circuit with a number of parallel-connected delay devices for detection of signal components of the CDMA signal which are transmitted via different signal paths,
having a channel estimation circuit for estimating channel coefficients of a combined transmission channel by means of a predetermined reference data sequence which is contained in the received CDMA signal,
having a coefficient calculation device for calculating weighting coefficients for the various signal components of the CDMA signal as a function of the estimated channel coefficients and of stored spreading and scrambling codes,
having a weighting circuit for weighting the signal components with the calculated weighting coefficients, and having a combiner for combining the weighted signal components to form an estimated received data signal for further data processing.

One advantage of the CDMA receiver according to the invention is that the conventional Rake receiver structure can be retained.

The CDMA receiver according to the invention effectively overcomes signal interference between different subscribers in one cell. This allows the number of subscribers within one cell to be increased, and the data can be transmitted at a higher data rate from the base station to the subscribers. The suppression of multi-access interference also reduces

the bit error rate by means of the CDMA receiver according to the invention.

The weighting coefficient calculation device is preferably connected to a memory device.

The memory device preferably stores spreading codes for the other subscribers as well as the scrambling code for the transmitter.

In one preferred embodiment, the combiner is an adder for addition of the weighted signal components.

The reference data sequence is preferably processed by the channel estimation circuit at the chip clock rate.

The delay devices in the Rake receiving circuit delay the reception of the CDMA signal with an associated time delay, with the time delay between the various delay devices preferably differing by precisely one chip clock cycle.

The receiving device preferably has a receiving antenna and a sampling circuit for sampling the received CDMA signal.

Furthermore, an output circuit is preferably provided for outputting the reference data sequence from the received CDMA signal.

In one preferred embodiment of the CDMA receiver according to the invention, the weighting circuit comprises a large number of multiplication circuits, which are each followed by a delay device.

In one particularly preferred embodiment of the CDMA receiver according to the invention, a buffer store is provided for buffer storage of the sampled CDMA received data.

The channel estimation circuit and the weighting coefficient calculation unit are preferably provided by a sequence in an appropriate algorithm in a DSP processor.

A preferred embodiment of the CDMA receiver according to the invention will be described in the following text in order to explain features which are essential to the invention, with reference to the attached figures, in which:

Figure 1 shows a schematic illustration of a mobile radio cell with a number of subscribers;

Figure 2 shows a simple data channel model;

Figure 3 shows a CDMA transmitter according to the prior art;

Figure 4 shows a CDMA receiver according to the prior art; and

Figure 5 shows one preferred embodiment of the CDMA receiver according to the invention.

As can be seen from Figure 5, the CDMA receiver according to the invention has a receiving antenna 1, which is used for receiving a CDMA signal which is transmitted from a base station and is received as the received signal e(t) by the antenna 1. The antenna 1 passes the received CDMA signal e(t) via a line 2 to an output node 3, which is connected via a line 4 to a signal input 5 of a Rake receiving circuit 6. The Rake receiving circuit 6 has a large number of delay devices 7_1, 7_2, 7_n. The delay devices 7 are connected in parallel with one another via internal signal lines 8_1, 8_2, 8_n, with the signal lines 8 being connected to the signal input 5 of the Rake receiving circuit 6. The

delay devices 7_1-7_n are connected on the output side via lines 9_1-9_n to multiplication circuits 10_1-10_n. The multiplication circuits 10_1-10_n respectively multiply the signal components of the CDMA received signal which are emitted from the delay devices 7_1-7_n by respective weighting coefficients m_1-m_n, which are emitted via lines 11_1-11_n from a weighting coefficient calculation device 12. The multiplier circuits 10_1-10_n together form a weighting circuit 13. The signal components emitted by the multipliers 10_1-10_n are emitted via lines 14_1-14_n to a combiner 15, which combines the various weighted signal components to form an estimated received data signal $\hat{d}(t)$ which is emitted via a data line 16 for further data processing in the receiver.

The CDMA signal e(t) received via the antenna 1 contains a reference data sequence which is output at the output point 3 by means of an output circuit 17. The output circuit 17 is for this purpose connected via a line 18 to the output node 3. The reference data sequence which is output by the output circuit 17 is supplied via a line 19 directly to a channel estimation circuit 20. The channel estimation circuit estimates the channel coefficients h of the physical transmission channel H by means of the output reference data sequence, and emits the determined channel coefficients h via a line 21 to the weighting coefficient calculation device 12.

The weighting coefficient calculation device 12 is connected via a memory read line 22 to a memory device 23. The spreading codes C_{SP} for the other subscribers U as well as the scrambling code C_{SC} for the base stations BS are stored in the memory device 23. The weighting coefficient calculation device 12 calculates the weighting coefficients m for the various signal components of the CDMA signal as a function of the estimated channel coefficients h, and of the stored spreading codes C_{SP} and scrambling codes C_{SC}. The

calculated weighting coefficients m are emitted via lines 11_1-11_n to the various multiplier circuits 10_1-10_n in the weighting circuit 13, where they are multiplied by the signal components emitted from the delay devices 7_1-7_n. The signal components weighted in this way are combined with one another in the combiner 15 to form an estimated received data stream $\hat{d}(t)$. The combiner 15 is in this case preferably an adder, which adds up the various weighted signal components.

A CDMA received signal is received through the antenna 1 by the receiver, and depends on the transmitted signal s and the physical transmission channel H. The physical transmission channel may be represented as a data matrix H comprising a large number of channel coefficients h. Using the vector notation, the received data vector e becomes:

$$\vec{e} = [H] \cdot \vec{s} \qquad (1)$$

The CDMA receiver may likewise be represented as a data matrix M, with the estimated data vector being obtained from the received data vector to give:

$$\vec{\hat{d}} = [M] \cdot \vec{e} \qquad (2)$$

The estimated data vector $\hat{d}$ thus depends on the data matrix H for the physical transmission channel, and on the receiver matrix M.

$$\vec{\hat{d}} = [M] \cdot [H] \ \vec{s} \qquad (3)$$

The transmitted data vector depends on the data d originally emitted from a data source to the transmitter, on the spreading code C_{SP} and on the scrambling code C_{SC}. As has already been explained in conjunction with Figure 3, the data stream d is first of all spread by means of a spreading code C_{SP} in the transmitter, and is then scrambled in a scrambling circuit by means of a scrambling code C_{SC}.

The estimated data vector thus becomes:

$$\vec{\hat{d}} = [M][H][C_{SP}][C_{SC}] \cdot \vec{d} \qquad (4)$$

Since the physical transmission channel (τ) and the spreading circuit and scrambling circuit are regarded as a combined channel, the coefficient matrix for the combined channel H' becomes:

$$[H'] = [H][C_{SP}][C_{SP}] \qquad (5)$$

The received estimated data vector $\vec{\hat{d}}$ thus depends on the coefficient matrix for the receiver M and on the coefficient matrix H' for the combined channel.

$$\vec{\hat{d}} = [M] \cdot [H'] \cdot \vec{d} \qquad (6)$$

In the case of an assumed, ideally estimated physical transmission channel, the coefficients m of the receiver matrix M must be set by the weighting coefficient calculation device 12 such that:

$$[M] \cdot [H'] \rightarrow \underline{I} \qquad (7)$$

where I corresponds to the unit matrix.

The signal coefficients h of the physical transmission channel H are received by the weighting coefficient calculation device 12 from the channel estimation circuit 20 via the line 21. The spreading coefficients C_{SP} of the orthogonal OVSF codes of the other subscribers are stored in the memory 23, and can be read by the weighting coefficient calculation device 12 via the line 22.

The scrambling code C_{SC} of the base stations BSs is likewise stored in the memory 23, and is read by the weighting coefficient calculation device 12 in order to calculate the channel coefficients for the combined channel H'.

The weighting coefficient calculation device 12 contains a processor, which carries out the calculation defined in equation 7 and calculates the weighting coefficients m of the receiver in such a manner that

the product of the receiver matrix M and of the channel coefficient matrix H' of the combined channel approximates to the unit matrix I.

As can be seen by comparing Figure 4, which shows the CDMA receiver according to the prior art, and Figure 5, which shows the CDMA receiver according to the invention, the circuitry of the CDMA receiver according to the invention is less complex. The Rake receiving circuit 6 of the CDMA receiver according to the invention comprises only the delay devices 7_1-7_n, and does not contain any descrambling circuits or despreading circuits for the respective signal components. Furthermore, the output circuit 17 in the CDMA receiver according to the invention is connected directly to the channel estimation circuit 20 via the line 19. The reference data sequence which is output by the output circuit 17 is processed by the channel estimation circuit 20 using the chip clock rate T_C and not using the symbol data clock rate T_D. The delay devices 7_1-7_n in the Rake receiving circuit 6 delay the received CDMA signal e(t) by an associated time delay τ, with the time delay τ differing by precisely one chip clock cycle T_C between the various delay devices 7_1-7_n.

The CDMA receiver according to the invention has the memory 23, in which the spreading codes C_{SP} of all the subscribers and the scrambling codes C_{SC} of the base stations BS are stored. This means that the CDMA receiver according to the invention can also take into account the orthogonal spreading codes of the other subscribers in the cell, and hence the signal received from them, when calculating the weighting coefficients m. In the process, the weighting coefficient calculation device 12 calculates the weighting coefficients m in such a manner that signal interference resulting from the CDMA transmitted signals emitted to the other subscribers is suppressed or overcome. In the process, the channel estimation

circuit 20 estimates the transmission channel H at the chip clock level T_C, and not at the data symbol level T_D.

The stored spreading codes for the other subscribers allow the CDMA receiver according to the invention to carry out multi-subscriber detection, which takes account not only of the intersymbol interference but also of multiple-access interference, and hence has improved spectrum efficiency.

List of reference symbols

1	Antenna
2	Line
3	Output node
4	Line
5	Signal input
6	Rake receiving circuit
7_1-7_n	Delay devices
8_1-8_n	Signal lines
9_1-9_n	Signal lines
10_1-10_n	Multiplication circuits
11_1-11_n	Lines
13	Weighting circuit
14_1-14_n	Signal lines
15	Combiner
16	Output line
17	Output circuit
18	Line
19	Line
20	Channel estimation circuit
21	Line
22	Memory read line
23	Memory device

Patent Claims

1. CDMA receiver for receiving a CDMA signal, which is transmitted at the chip clock rate from a transmitter via various signal paths of a physical transmission channel, in a multi-subscriber environment having:
(a) a receiving device (1) for receiving the CDMA signal;
(b) a Rake receiving circuit (6) having a number of parallel-connected delay devices (7_1-7_n) for detection of the signal components of the CDMA signal which are transmitted via the various signal paths;
(c) a channel estimation circuit (20) for estimating channel coefficients h of a transmission channel H by means of a predetermined reference data sequence which is contained in the received CDMA signal;
(d) a weighting coefficient calculation device for calculating weighting coefficients m for the various signal components of the CDMA signal as a function of the estimated channel coefficients h and of stored spreading and scrambling codes;
(e) a weighting circuit (12) for weighting the signal components with the calculated weighting coefficients m; and having
(f) a combiner (15) for combining the weighted signal components to form an estimated received data signal.

2. CDMA receiver according to Claim 1, characterized in that the weighting coefficient calculation device (12) is connected to a memory device (23).

3. CDMA receiver according to Claim 1 or 2, characterized in that spreading codes C_{SP} of the subscriber and scrambling codes C_{SC} from the transmitter are stored in the memory device (23).

4. CDMA receiver according to one of the preceding claims,
characterized
in that the combiner (15) is an adder for adding the weighted signal components.

5. CDMA receiver according to one of the preceding claims,
characterized
in that the reference data sequence is processed by the channel estimation circuit (20) at the chip clock rate T_c.

6. CDMA receiver according to one of the preceding claims,
characterized
in that the delay devices (7_1-7_n) of the Rake receiving circuit (6) delay the received CDMA signal by an associated time delay τ, with the time delay τ differing by precisely one chip clock cycle T_c between the various delay devices.

7. CDMA receiver according to one of the preceding claims,
characterized
in that the receiving device (1) is a receiving antenna, which is followed by a sampling circuit for sampling the CDMA received signal.

8. CDMA receiver according to one of the preceding claims,
characterized
in that an output circuit (17) is provided for outputting the reference data sequence from the received CDMA received signal.

9. CDMA receiver according to one of the preceding claims,
characterized

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
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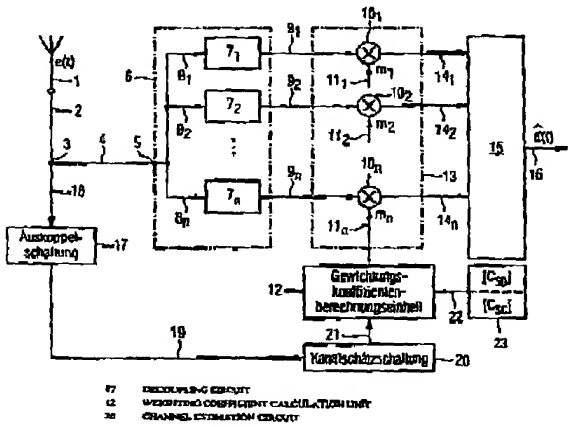
[Fortsetzung auf der nächsten Seite]

(54) Title: CDMA RECEIVER

(54) Bezeichnung: CDMA-EMPFÄNGER



(57) Abstract: The invention relates to a CDMA receiver for receiving, in a multiple subscriber environment, a CDMA signal transmitted with a chip rate by a transmitter via different signal paths of a physical transmission channel. Said CDMA receiver comprises: a receiving device (1) for receiving the CDMA signal; a rake receive circuit (6) with a number of parallelly connected delay devices (7_1-7_n) for detecting the signal components of the CDMA signal that are transmitted via the different signal paths; a channel estimation circuit (20) for estimating the channel coefficients h of a transmission channel H by using a predetermined reference data sequence contained in the received CDMA signal; a weighting coefficient calculation device for calculating weighting coefficients m for the different signal components of the CDMA signal according to the estimated channel coefficients h and to the stored spread codes and scrambling codes; a weighting circuit (12) for weighting the signal components with the calculated weighting coefficients m, and; a combiner (15) for combining the weighted signal components to form an estimated received data signal.

(57) Zusammenfassung: CDMA-Empfänger zum Empfangen eines mit Chiptakt von einem Sender über verschiedene Signalpfade eines physikalischen Übertragungskanals übertragenen CDMA-Signals in einer Mehrteilnehmerumgebung mit: einer Empfangseinrichtung (1) zum Empfang des CDMA-Signals; einer Rake-Empfangsschaltung (6) mit mehreren parallel geschalteten Verzögerungseinrichtungen (7_1-7_n) zur

[Fortsetzung auf der nächsten Seite]

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in that the weighting circuit (13) comprises a large number of multiplication circuits (10_1-10_n), which are each followed by a delay device (7_1-7_n).

10. CDMA receiver according to one of the preceding claims,
characterized
in that a buffer store is provided for buffer storing the sampled received data from the CDMA received signal.

11. CDMA receiver according to one of the preceding claims,
characterized
in that the channel estimation circuit (20) is a DSP processor.

12. CDMA receiver according to one of the preceding claims,
characterized
in that the weighting coefficient calculation device (12) is a DSP processor.

13. CDMA receiver according to one of the preceding claims,
characterized
in that the memory device (23) is an RAM memory.

FIG 1

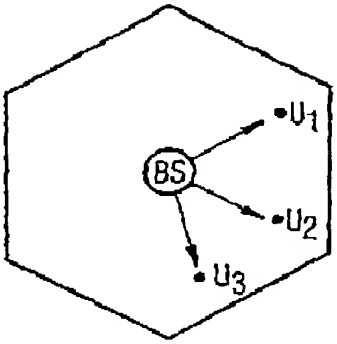


FIG 2

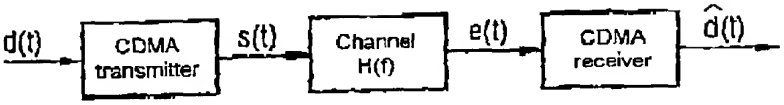


FIG 3

Prior art

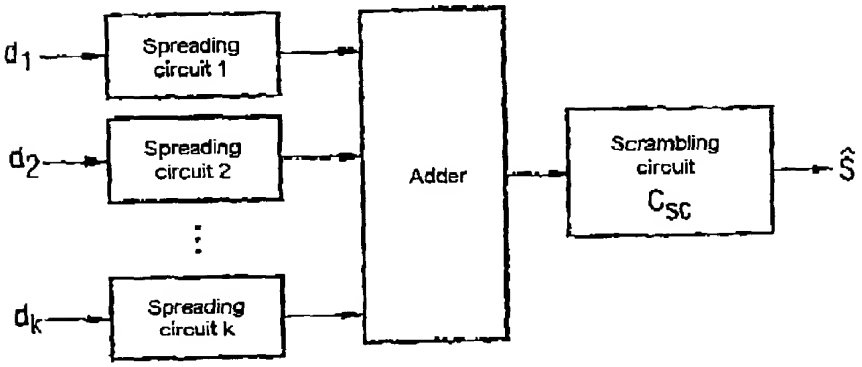
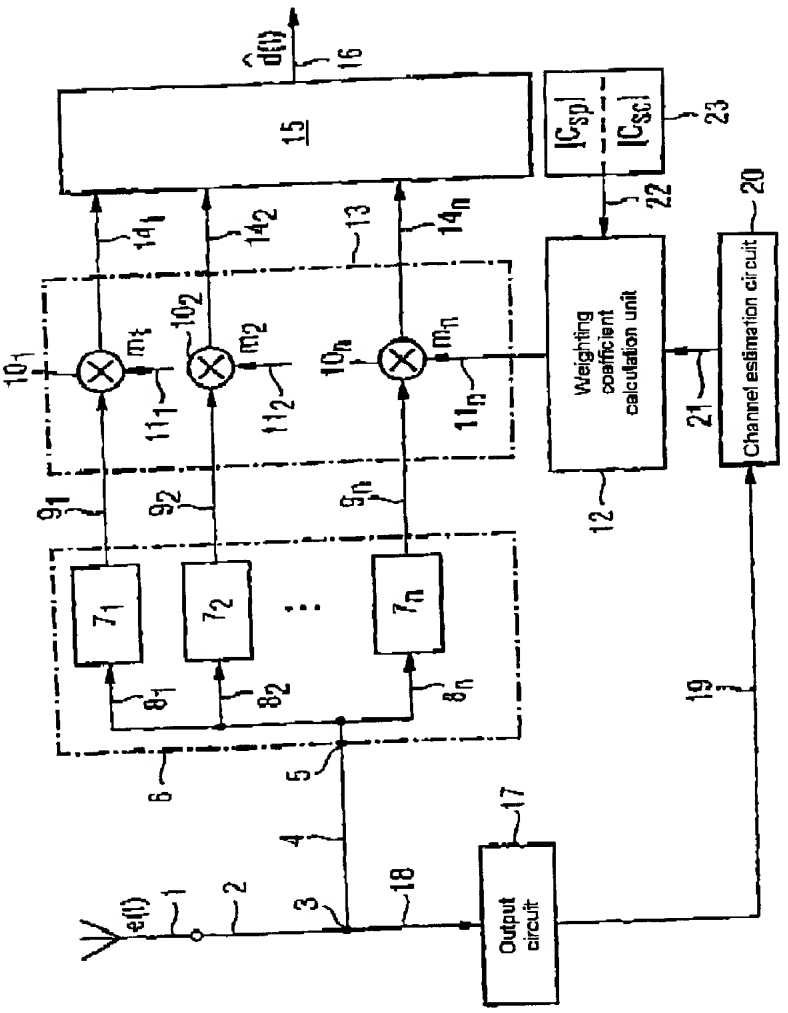


FIG 5


15
16
23
22
20
Weighting coefficient calculation unit
Channel estimation circuit
21
12
19
17
Output circuit
18
1
2
3
4
5
6

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☒ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	1406/18
First Named Inventor	Doetsch, Markus
COMPLETE IF KNOWN	
Application Number	09 / 936,771
Filing Date	September 14, 2001
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

CDMA RECEIVER

(Title of the Invention)

the specification of which

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY) 09/14/2001 as United States Application Number or PCT International

Application Number 09/936,771 and was amended on (MM/DD/YYYY) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	Certified Copy Attached? NO
100 01 649.9	Germany	01/17/2000	☐	☐	☒
PCT/EP01/00494	WIPO	01/17/2001	☐	☐	☒
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

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NAME OF SOLE OR FIRST INVENTOR : [ ] A petition has been filed for this unsigned inventor

Given Name (first and middle [if any]): Markus | Family Name or Surname: Doetsch

Inventor's Signature | Date

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Mailing Address Sendnicher-Weg 62

City Koblenz | State | ZIP 56072 | Country Germany

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Residence: City München | State | Country DE | Citizenship DE

Mailing Address Tumblingerstr. 54/42

City München | State | ZIP D-80337 | Country Germany

[X] Additional inventors are being named on the ____supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

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Inventor's Signature | Date 22.10.01

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Page 1 of 2

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Mailing Address: Im Rabental 28			
Mailing Address			
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Mailing Address			
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Mailing Address			
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Inventor's Signature			Date
Residence: City Otterberg	State	Country DE	Citizenship DE
Mailing Address: Im Rabental 28			
Mailing Address			
City Otterberg	State	ZIP D-67697	Country Germany

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Inventor's Signature			Date
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Mailing Address			
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Mailing Address			
City	State	ZIP	Country
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